CLIMATE CHANGE ADAPTATION STRATEGY
CITY of FREDERICTON

Stakeholder Input

ETF Project Number 070280

FINAL REPORT

Submitted to:
New Brunswick
Department of Environment

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Submitted by:
Environment and Sustainable
Development Research Centre (ESDRC)

in Association with
RILEY ENVIRONMENT LIMITED
Environment Canada
Fredericton Area Watershed Association

ESDRC

Environment Canada Environnement Canada

New Nouveau Brunswick

Report

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CITY of FREDERICTON
Stakeholder Input
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TABLE OF CONTENTS

Table of Contents
(continued)

Page

Figures

Tables

1.0 INTRODUCTION

1.1 Background

Fredericton, which is the capital of New Brunswick, is located along the St. John River in the central part of the Province of New Brunswick. With a population of 50,000, Fredericton is a typical small urban Canadian municipality facing the economic, social, and environmental consequences that result from climate change. Fredericton has recognized these consequences and has moved forward with several initiatives to mitigate greenhouse gases (GHG), and to adapt to the impacts of climate change at both the citizen and corporate levels.

Fredericton (the City) has long been recognized as a 'green' city, with a strong track record for environmentally focused activities and programs. In 2007, Fredericton moved to become a Green Community with its Green Matters campaign. This campaign focuses on more environmentally friendly practices in the City both on the part of City Hall and the residents. During the past year there has been a drastic change in public attitude towards greening the environment.

The primary focus of Green Matters to date has been climate change and what stakeholders need to do to reduce GHGs, i.e. mitigation. The City is working towards reducing its corporate GHG by 20 percent and community emissions by 6 percent by 2010, a goal that is readily attainable. Fredericton's goal is to become the first city in Canada to be in compliance with Kyoto targets. Green Matters has been successful in educating the public of the unquestionable urgency of reducing GHG emissions. However, measures to reduce emissions are only part of the climate change challenge. The reality is that, even if significant reductions in emissions are made tomorrow, gases already in the atmosphere will continue to affect the climate for several decades to come due to the lag in the climate system. Without an understanding of both mitigation and adaptation there is a real danger that actions taken to address one could actually negatively impact the other.

In May 2007, the Environment & Sustainable Development Research Centre (ESDRC) at the University of New Brunswick (UNB), in partnership with the Fredericton Area Watersheds Association (FAWA), Riley Environment Limited, and Environment Canada, was awarded funding under New Brunswick's Environmental Trust Fund (ETF) to assist the City in the development of a Climate Change Adaptation Strategy (CCAS). The following report and attachments present the results of this project

1.2 Project Goal

The initial goal of this CCAS project is to develop an approach to climate change adaptation that will allow Fredericton stakeholders to make the informed decisions necessary to adapt to climate change.

However as the project progressed, the goal shifted towards stakeholder input to the process based on information provided by the Study Team.

1.3 Organization of Report

The following Report presents the results of the CCAS project. It includes projected climate scenarios for Fredericton, a summary of potential risks and adaptative measures based on the experiences of other jurisdictions, and a summary of Fredericton's stakeholders concerns and suggested approaches to climate change adaptation. A copy of the agenda and background document for the charette is provided in Appendix A. A summary of stakeholder comments is provided in Appendix B.

2.0 METHODOLOGY

Adaptation is the only response available for the climate change impacts that will occur over the next several decades before today's *mitigation* measures will have an effect. The workplan for the project was balanced between delivering the *adaptation* message, in conjunction with the *mitigation* message, in a manner that demonstrates the requirement for both. This project is complementary to Fredericton's Green Matters campaign.

The overall approach for this project is based on the UKCIP approach which has been used successfully throughout the United Kingdom. The UKCIP approach can best be described as a "bottom-up" rather than a "top-down" approach in that science enables the process, but the stakeholders drive it. However, top down science also drives it in terms of federal and provincial legislation that has bearing on climate change adaptation.

The project was carried out in three phases as discussed below.

Phase I Climate Change Scenarios

The impact on the City inhabitants will be significant as a result of increased temperatures, increased precipitation, and greater incidence of extreme events. The first phase involved the development of climate change scenarios for the City for three time slices in the future, 2020s, 2050s, and 2080s.

Projected changes to Fredericton's climate were determined by Environment Canada under various

GHG assumptions.

Phase II Stakeholder Mobilization

The second phase of the project was the mobilization of stakeholders, defined as anyone who lives and/or works in Fredericton. Stakeholder involvement was critical to the success of the project. The following is a summary of the stakeholder involvement activities carried out by the Study Team over the course of this project.

i) Presentation to City Council. On September 18 2007, the Study Team made a presentation to Fredericton City Council. The presentation outlined the objectives of the project and the proposed workplan for the next six months.
ii) Meeting with City Staff. On December 14 2007, the Study Team met with senior department managers of the City to present the climate scenarios as determined by Environment Canada. Input was also sought from Staff on potential adaptative measures.
iii) Web page. The website "adaptationfrederiction.ca was launched on February 8 2008 by the Study Team. This website was used to both as a vehicle to deliver adaptation information to the stakeholders including the announcement of any project activities, as well as another forum for stakeholders to input to the process.
iv) Townhall Meetings. Townhall meetings were facilitated by the Study Team on February 12 and March 18, 2008. The February 12 meeting at the Wu Centre was co-sponsored by the Fredericton Branch of the Association of Professional Engineers and Geoscientists with the March 18 meeting at MacLaggan Hall co-sponsored by FAWA. Both public meetings were advertised in advance in Fredericton's Daily Gleaner. All stakeholder comments were recorded by the Study Team.
v) Daily Gleaner. The Daily Gleaner ran a story on February 12,2008 about Climate Change Adaptation in which information on the townhall meeting, webpage, etc was provided to the newspaper readers.
vi) CBC Radio. On March 13, the Project Leader was interviewed on CBC Radio on the project. Excerpts of the interview were replayed throughout the day on each CBC news broadcast.

Phase III Charette

On March 13, a one day charette was held at the Wu Centre with 28 selected stakeholders and the Study Team. The charette involved a number of breakout sessions to first identify potential risks of climate change based on the scenarios determined by Environment Canada, and then potential adaptative measures. A copy of the charette agenda is provided in Appendix A. All stakeholder comments were recorded.

Summary

Over seventy-five Fredericton stakeholders have participated in one or more of the activities sponsored by the Study Team over the period September 2007 to March 2008. In addition, at the end of March, 2008, there were over three hundred visits to "adaptationfrederiction.ca".

Summaries of stakeholder comments from the townhall meeting (February 12) and Charette are provided in Appendix B.

3.0 MITIGATION vs ADAPTATION

The initial hurdle that the Study Team encountered was the differentiation between adaptation and mitigation with stakeholders. The general public, because of the international focus on GHG reduction (i.e. Kyoto Protocol, Inconvenient Truth), has a tendency to consider climate change only in terms of GHG reduction. The United Nations Convention on Climate Change (UNCCC) identities both mitigation and adaptation as options to address climate change where mitigation is defined as:

> *"anthropogenic intervention to reduce sources or enhance the sinks of greenhouse gases*"

and adaptation is defined as:

> *"building resilience into our system by increasing our ability to deal with current climate, preparing to take advantage of new opportunities, and reducing risks and costs of future climate change".*

As noted previously, the impact of significant reductions in emissions tomorrow, because of the lag in the climate system, will only manifest in 20-30 years. Thus, emissions already in the atmosphere will continue to affect the climate for several decades to come. Without an understanding of both mitigation and adaptation there is a real danger that actions taken to address one could actually make the other worse.

Adaptation responses can be categorized as measures and strategies that contribute either to:

- Building adaptative capacity by creating the information (research, data collecting and monitoring, awareness raising), supportive social structures, and supportive governance that are needed as a foundation for delivering adaptation options.
- Delivering adaptation actions that help to reduce the vulnerability to climate change, or to exploit opportunities.

Both mitigation and adaptation are essential in reducing the risks of climate change in that both seek to avoid the potential damages of climate change and both seek to support the development of present and future generations in a sustainable manner. However, the influence and incidence of

employing them as climate change policy instruments are different[1] .

In differentiating between mitigation and adaptation there are both commonalities and differences which distinguish the two. Table 3.1 provides a summary of the main commonalities and differences between mitigation and adaptation.

Table 3.1
Commonalities and Differences between Mitigation and Adaptation
(Source: Dang et al., 2003)

	Mitigation	Adaptation
Common target	Sustainable development	Sustainable development
Distinct characteristics	Proactive action, long term reduction of climate change impacts	Reactive action, iterative depending on the real impacts of climate change. Proactive if based on results
Temporal effect	Benefits to latter generations	Benefits can be more or less appropriated by those bearing costs.
Geographical effect	Global effects but varying across regions	Primarily local benefits
Cooperation degree required	Global	National, regional
Sectoral effect	Focus on emissions from fossil fuels	Very heterogeneous with some stress on agriculture
Relation to uncertainty	Setting of emissions targets has to be adjusted to regularly take into account new projections.	Reactive adaptation can wait until more concrete evidence of climate impacts available. Successful proactive adaptation has difficulties to justify itself as the 'baseline' impacts are unknown
Equity	Free-riding problem, especially motivated with countries less vulnerable to climate change	Unfair, the victims are not always responsible for causing climate change
Secondary Benefit	Some options have high local secondary benefits (e.g. reduce air pollutants). Some options may even be financially viable. Technology transfer	Some options are beneficial in the absence of climate change- "win-win" option Technology transfer

[1] Hall,J.,Walsh,C.,(2007). Linking adaptation and mitigation strategies. SKCC

Despite the differences between adaptation and mitigation, both are essential in reducing the risks of climate change.

The Study Team opened both townhall meetings as well as the charette with a discussion of the adaptation vs. mitigation issue. Examples have been provided where the two approaches are in conflict and instances where there are definite synergies. The Fredericton stakeholders involved in this project, based on responses received, have been able to differentiate between the two options

4.0 CLIMATE CHANGE SCENARIOS FREDERICTON

4.1 Climate Change Scenarios

A climate change scenario can be defined as "a coherent, internally consistent and plausible description of a possible future state of the world…" [Parry, 2002]. Climate scenarios are not predictions of future climate. They are typically used to assess impacts of climate change, address vulnerability to change and to develop adaptation strategies or actions.

There are many ways of developing scenarios such as adopting a past event (analogue technique), increasing or decreasing climate parameters by arbitrary amounts, global climate models (GCMs) and methods derived from GCMs like statistical downscaling and regional climate models. In this project we have used information from GCMs to provide future climate scenarios.

4.2 Global Climate Models

Global climate models (GCMs) are complex numerical models of the climate system. Because of their complexity and the significant resources required to manage them, there are a limited number of global climate modeling groups around the world. The Canadian Centre for Climate Modeling and Analysis (CCCma, 2008) is one of the recognized centers of climate modeling expertise. Using climate models, numerical experiments can be performed which indicate the impact of changes to the climate system due to modifications to the atmospheric greenhouse gas and aerosol composition. GCM output underpins the results of the fourth IPCC assessment report released in 2007. The most recent model results are the so-called AR4 runs which supported the IPCC 4th assessment (IPCC, 2008). The AR4 modeling results are the ones adopted for this project.

4.3 Emission Scenarios

Many factors interact to drive climate but the most important is concentration of radioactively active gases in the atmosphere. Future emissions (and therefore concentrations) of greenhouse gases will be driven by population growth, economic growth and energy use. Various scenarios of atmospheric greenhouse concentrations have been advanced. So as to be intercomparable, most modeling groups have recently adopted the A2, A1B and B1 scenarios for greenhouse gas concentrations. On a global scale the resulting temperature change for these scenarios is illustrated by Figure 4.1. These scenarios can be thought of as high, medium and low assumptions. Figure 4.1 also shows a fourth hypothetical scenario, i.e. the result if one were to freeze the atmosphere at Year 2000 concentrations.

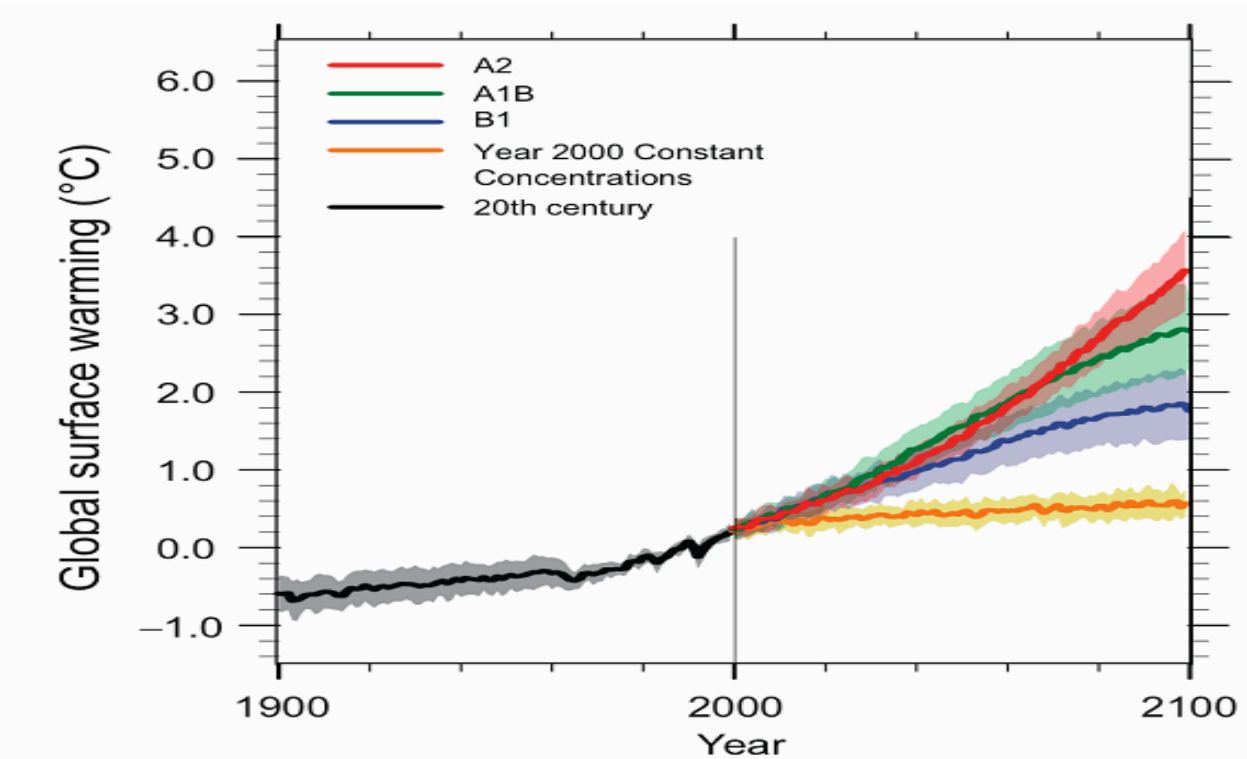

Figure 4.1 Global surface warming for four emission scenarios (IPCC SPM.5, IPCC (2008))

4.4 Climate Change Scenarios

The Adaptation and Impacts Research Division (AIRD) of Environment Canada has invested heavily in making available climate scenarios from GCM experiments carried out by modeling groups around the world. These data are publicly available on the Canadian Climate Change Scenarios Network (CCCSN) at www.cccsn.ca. The site also provides downscaled estimates of different climate indices through the bioclimate profiles option.

In this project we considered the range of scenario results but have concentrated on the middle or A1B scenario for demonstration purposes. The A1B scenario describes a future world of very rapid economic growth, low population growth, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1B scenario assumes a balanced mix of fossil and non-fossil fuels in the energy mix.

4.5 Model Selection

Results from about 20 models for the A1B scenario are available from the CCCSN site (CCCSN, 2007). Evaluation of all of them was beyond the resources available for this project. Scenarios from the most up-to-date Canadian GCM (CGCM3) for three thirty-year time slices between 2011 and 2100 were evaluated against the results from other models. It was found that the CGCM3 results were comparable to others, and well within the range of variability of predictions. We therefore chose to use the CGCM3 model under the A1B emission scenario as the basis for climate scenarios for Fredericton.

4.6 Global to Regional Scale

The climate changes illustrated in Figure 4.1 are for the global average. Further refinement is necessary to apply impact and adaptation analysis to a particular location. The grid for the CGCM3 model is illustrated by Figure 4.2. For this study we used results from the nearest grid box which is shown by the dark outline.

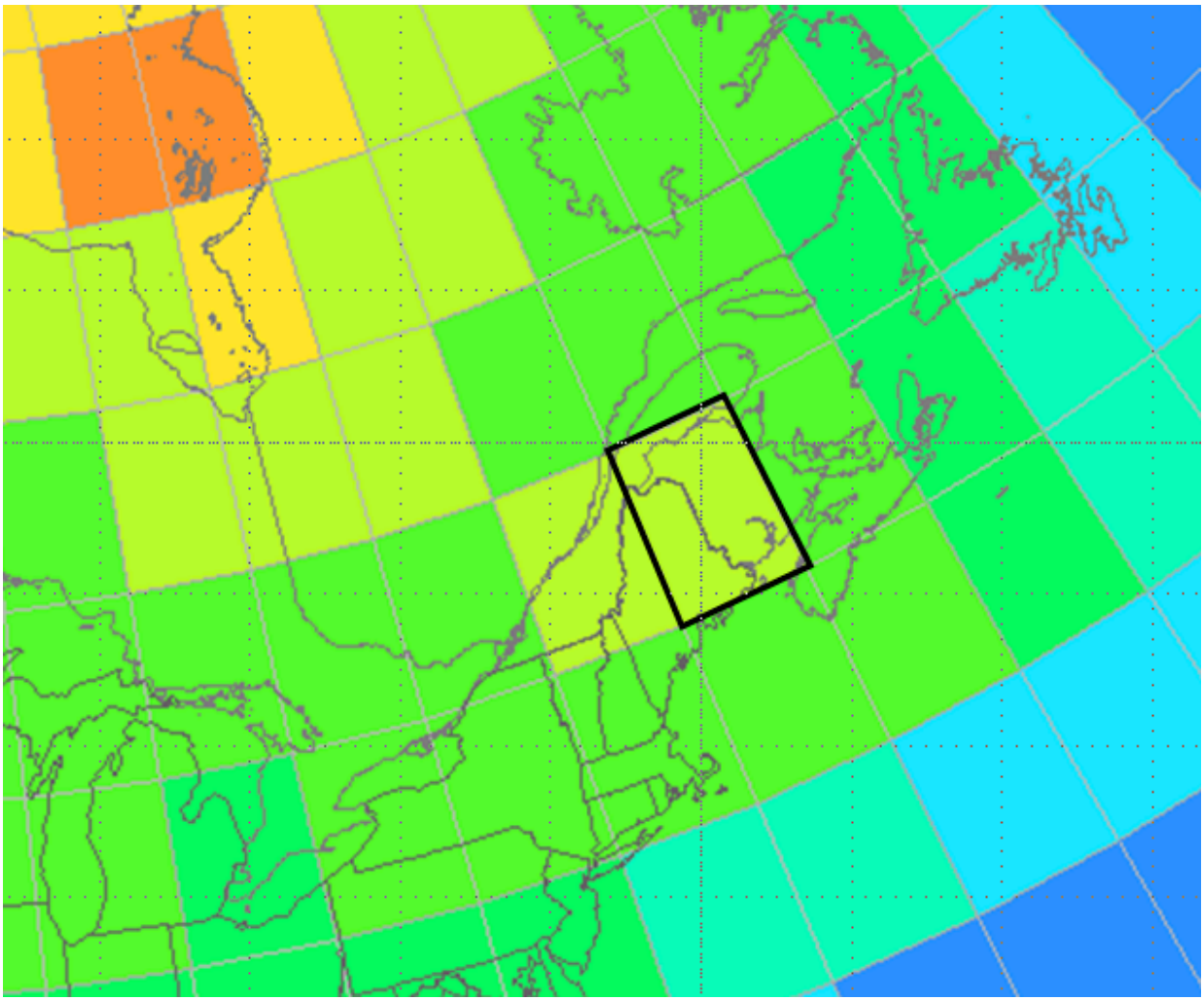

Figure 4.2 Grid for CGCM3 Global Climate Model showing selected grid square over New Brunswick (from CCCSN)

4.7 Climate Scenario for Fredericton

Tables 4.1 to 4.8 show the temperature and precipitation changes as well as how various climate indices may change during the 21st century based on the assumptions detailed above. These changes are all referenced to the 1971-2000 historical period where applicable. The time periods are thirty year averages where the 2020's refers to the period 2011-2040, 2050's refers to 2041-2070 and 2080's refers to 2071-2100.

Table 4.1
Mean Temperature Change (ºC) –Fredericton

	2020's	2050's	2080's
Winter	1.3	3.7	4.6
Spring	1.6	2.7	3.8
Summer	1.3	2.4	3.2
Autumn	1.0	2.2	3.1

Table 4.2
Mean Precipitation Change (%)-Fredericton

	2020's	2050's	2080's
Winter	1.1	17.4	24.1
Spring	9.7	16.1	18.1
Summer	-3.0	-2.2	-5.6
Autumn	0.1	4.8	7.0

Table 4.3
Heating and Cooling Degree Days-Fredericton

	Heating Degree Days	Cooling Degree Days
1971-2000	4742	141.6
2020's	4245	242.7
2050's	3794	331.3
2080's	3524	411.6

Table 4.4
Growing Days-Fredericton

	Growing Degree Days (>5 ºC)	Growing Season Length (Days)	Freeze-Free Season (Days)
1971-2000	1774	162.3	187
2020's	2110	188	216
2050's	2364	206	232
2080's	2579	277	247

Table 4.5
Precipitation Days-Fredericton

	Days With Rain	Days With Snow
1971-2000	121	29
2020's	114	24
2050's	121	20
2080's	126	18

Table 4.6
Extreme Temperatures-Fredericton

	Days With Maximum Temperature >30 ºC	Days With Maximum Temperature >35 ºC	Days With Maximum Temperature < -10 ºC
1971-2000	8	0	12
2020's	19	2	8
2050's	29	3	3
2080's	36	5	3

Table 4.7
Freeze –Thaw-Fredericton

	Annual Freeze-Thaw Cycles	Freeze-Thaw Cycles (in Winter)
1971-2000	106	9.9
2020's	92	11.5
2050's	92	14.5
2080's	82	14.8

4.8 Summary

Following is a summary of anticipated changes to Fredericton weather over the next 72 years:

- Warmer temperatures all seasons with most warming in winter
- Increased precipitation overall with wetter winter/springs and drier summers
- Fewer freeze-thaw cycles annually but more freeze-thaw cycles in winter
- Fewer cold days
- More hot and very hot days
- More days with rain & fewer days with snow

- Increased runoff but increasing drought
- Longer freeze-free season
- Increase in growing season
- Fewer heating degree days but Increase in cooling degree days

5.0 ADAPTATION

5.1 Background

Adaptation refers to any modification in a system or process made in response to changing climate. Adaptation involves making adjustments in our decisions, activities and thinking because of observed or expected changes in climate, with the goals of moderating harm or taking advantage of new opportunities.[2]

While the concept of adaptation is simple, the process of adaptation within human systems is complex. Adaptation actions are tremendously diverse and may involve behavioral changes; operational modifications; technological interventions; and revised planning and investment practices, regulations and legislation. The most appropriate adaptation actions for any given issue are determined by a wide range of social, economic and environmental factors many cases, adaptation will involve careful planning, guided by both scientific research on climate change and detailed understanding of the systems involved.[3]

The following Table 5.1 provides an explanation and examples of various measures (actions) to adaptation to climate change. Each action is effective in its own right in addressing the issue.

[2] Intergovernmental Panel on Climate Change, 2001b).
[3] Impacts to Adaptation: Canada in a Changing Climate (2008)

Table 5.1
Adaptation Measures
(Government of Canada, 2004)

Adaptation Measure	Explanation	Example
Tolerate the Loss .	Do nothing to reduce vulnerability and absorb losses.	Allow household lawns and gardens to wither
Prevent the Loss	Adopt measures to reduce vulnerability to climate change	Protect coastal communities with Seawalls or groins
Spread or Share the Loss	Do not reduce vulnerability, but rather spread the burden of losses across different systems or populations.	Crop Insurance
Change the Activity	Stop activities that are not sustainable under the changed climate, and substitute with other activities.	Make Ski-resort a four season facility to attract tourists year round
Change the Location	Move the activity or system	Move ice fishing operations farther north .
Enhance the adaptive capacity	Enhance the resiliency of the system to improve its ability to deal with stress	Better building design to increase resiliency to CC impacts. Also reduces energy consumption

The adaptation actions identified by Fredericton stakeholders covered the full spectrum of approaches available.

5.2 Climate Change Risks and Adaptation Measures Assessment

As part of the engagement of stakeholders in the adaptation process, the Study Team initially focused on other communities both nationally and internationally which have addressed the climate change issue. A review of the published literature identified a wide range of potential risks to all sectors of our society from a changing climate as well as various adaptative measures to address these risks. This information was used by the Study Team as the foundation of subsequent discussions with stakeholders.

The Study Team selected the Fredericton Municipal Plan (Plan) to be a focal point for discussions with stakeholders. The Plan adopted by City Council in January 2007 provides a guide to the future growth of the City and defines a broad vision for the City; progressive and modern with a unique charm and character designed for people. It also establishes a broad planning framework and provides policy guidance on a variety of land-use and development-related issues anticipated in the years to come. In assessing potential risks, the Study Team looked at each section of the Plan individually using the predicted Environment Canada climate changes. A summary of potential risks was developed from the information extracted from the existing literature. In a similar fashion, a summary of potential adaptative measures was developed.

The following tables summarize the results of this assessment. The information on potential impacts from climate change and selected adaptive measures extracted from the literature is presented under the various sector heading of the Municipal Plan. An additional sector, built environment, has been added. To facilitate discussion, sections of the Plan have been grouped under socio economic (Table 5.2), infrastructure (Table 5.3), and Environment (Table 5.4). The lists of impacts and adaptive measures presented are not meant to be exhaustive but rather are provided as a basis for discussions.
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Table 5.2
Potential Risks and Adaptative Measures
Socio-Economic

Sector	Potential Risks	Adaptative Measures
Commercial (2.6)	Vulnerability of supply chain Vulnerability of premises Cost of Insurance for business claims Weather affects consumer behavior which affects what they buy Threat to working conditions and travel arrangements for staff Business growth in outdoor activities	Climate risk management Optimize location of new premise Market research and product development with climate change in mind Sustainable construction for new commercial buildings
Industrial/Business (2.7)	Business interruption Impact on production processes and service delivery Vulnerability of supplies of goods	Sustainable construction Climate risk management New products or modifications to existing product to respond to

	and services Office environment uncomfortable as a result of increased summer heat Workforce experiencing difficulty getting to work in extreme weather conditions Cost of Insurance for business	changing market More outdoor activity Sustainable construction of new facilities
Economy (2.8)	Shifting markets Business failure or reduced profits Changing holiday patterns of workforce. Vulnerability of premises and transport systems for goods Impacts to agriculture	Building adaptative capacity Mainstream climate impacts and adaptation into conventional business strategy and management Review and update legislation, regulations, policy and procedures wrt climate change Identification of new markets/opportunities Changing lifestyle Climate proofing

Table 5.3
Potential Risks and Adaptative Measures
Infrastructure

Sector	Potential Risks	Adaptative Measures
Housing (2.5)	Existing buildings not well adapted to new climate Building fabric vulnerable to weather extremes Pest damage to buildings Mould Loss of Building value	Design New building design in anticipation of changed climate(National Building Code) Sustainable construction Improved design standards for construction industry Improved construction materials
Transportation(2.9)	Flooding/washouts Increased roadway base and subbase duress due to freeze thaw Increased pavement duress More intense maintenance	Floodproofing roads Relocation of roads, transportation networks Multiple road networks that provide more than one access

	operations	point. Better road design Roadway Management Plan
Municipal Services (2.10)	Localized flooding Soil erosion, landslides Risks (drought) to potable water supply Interruptions in energy supply Sanitary sewer and storm water backup Overloading sewage treatment facilities Health issues related to sewer backup	Stormwater management systems (Best Management Practices) Open space used for floodwater storage (flood control/dykes) Alternative sources of water, water storage. Flood risk mapping-municipal control of floodplains Alternate energy sources Energy and water neutral development policies
Built Environment	Property damage Internal environment (Increased Ventilation and cooling requirements) Structural damage Service infrastructure Increased site runoff	Buildings designed with backup energy systems Sustainable development Location Outdoor Spaces Better engineered materials Emergency planning

Table 5.4
Potential Risks and Adaptative Measures
Environment

Sector	Potential Risks	Adaptative Measures
(Natural) Environment (2.11)	Distribution and species composition of habitats Increase in invasive non-native species Lower low flows of Saint John River Impacts to recreation fishermen Summer droughts leading to tree mortality.	Different plant species for parks and gardens Different tree species for city streets

Recreation (2.12)	Increased outdoor sport and recreation Damage to sport and recreation facilities Reduced soil moisture will affect playing fields Overuse of outdoor (fields) facilities Increase in water based recreation and sports	Parks and Recreation Planning Outdoor facility management. Alter grass cover species. All weather fields Location of facilities
Heritage and Culture(2.13)	Loss of cultural and heritage structures	Improved management and maintenance of current buildings Development of climate change adaption strategies.

The information in the above tables was presented to and discussed with the stakeholders who attended the February 12 and March 18 townhall meetings. For the March 13 charette, the information was summarized in a Background Document which was provided to all invited participants prior to the charette. A copy of the Background Document is provided in Appendix A.

6.0 CLIMATE CHANGE RISKS

As indicated, the Study Team initially presented stakeholders risks from climate change identified in other jurisdictions (Chapter 5) and then solicited input as the potential risks for Fredericton based on the Environment Canada scenarios (Chapter 4). Socio-economic, infrastructure and environment issues were all discussed. While stakeholder comments were wide ranging and covered all aspects of life in Fredericton, a number of the issues dominated.

As part of the charette, all comments related to both the risks and adaption measures were recorded on flip charts during the breakout sessions. Participants were provided with a total of ten makers and requested to indicate their priorities (potential risk and adaptation measures) of the comments recorded. The following sections provide a summary of the principal risks identified by the stakeholders. The bracketed number at the end of selected comments is a record of the number of participants who considered it a priority.

6.1 Built Environment

The built environment, particularly housing, was identified repeatedly by stakeholders as being at risk due to climate change. Following is a summary of key points brought forward:

- Storm events will impact building envelope and structure. Potential water infiltration
- Increased temperatures will lead to more discomfort
- Increased precipitation will result in more humidity
- Siting of buildings is more important due to weather, transportation connections, and solar control
- Aging population combined with weather events will result in increased demand for emergency preparedness
- Cultural challenge to be part of a community that is sustainable
- The social impacts of increased cooling and heating and heating impacts the poor

6.2 Housing

Housing is part of the built environment. Stakeholders however, singled housing as a major risk from climate change. Following is a summary of key points brought forward:

- Climate ready condition of existing housing stock (1)
- If there is a new standard (ieR2000) for housing, does value of existing housing stock diminish?
- Total operating expenses for housing stock overall may stay the same but distribution of costs changes
- Need help to retrofit/ upgrade existing housing stock
- Disproportionate burden for improvements placed on those least able to bear cost. (7)
- Displacement of poor from downtown

6.3 Municipal Services

The following is a summary of key points brought forward with respect to existing municipal services:

- There will be an increase in recharge of well fields due to increase in precipitation/less runoff
- Increase in population coupled with drought conditions may test water supply capacity
- Seasonal variations in precipitation could impact ground water supply. Low water drought conditions
- Increased demand for water in surrounding areas may be more impacted from climate change because of their reliance on individual wells
- Surface water quality will decrease due to decrease in dilution (rivers) (1)
- Increased peak runoff require storm water management (2)
- Lower river flow-impact on sewage treatment
- Preparedness for extreme events when they happen (fall floods rather than spring). (1)
- Continued emphasis on water management for flood/storm events

6.4 Transportation

Transportation was another sector at risk identified by the stakeholders. In the case of transportation, potential risks also impact other sectors of Fredericton (i.e. business). The following is a summary of key points brought forward with respect to transportation:

- Adaptation will be incremental
- Freeze thaw increasing wear on transportation network
- Longer period for weight restrictions
- Potential deicing impact on some watershed areas
- Shift in summer/winter maintenance budgets
- Variability in climate will affect travel patterns
- Costs of road construction will increase
- More biking, walking trails, river
- Alternative transportation means (fuel cell)

6.5 Recreation and Parks

Stakeholders identified a number of risks associated with recreation and parks. The following is a summary of key points brought forward with respect to recreation and parks:

- Climate change will result in increased length of summer sports season and shorter winter sports season
- Possible increased costs to maintain sports facilities
- Increased costs to cool arenas in summer
- Fewer snow days will impact skiing, snowmobiling, etc.
- Demand for water recreation will increase
- Demand for recreational facilities will increase (3)
- Potential for more forest fires in parks/neighborhoods .Increased summer forest fires impact water supply/road access in parks
- Increased winter ice storms (6)
- Increased costs for tree/trail maintenance (transportation/cleaning fallen trees, etc.

6.6 Business/Economy

Stakeholders identified a number of risks associated with business/economy. The following is a summary of key points brought forward with respect to business/economy:

- Business location impacted by transportation risks (automobile)
- There are social risks with new approaches to business such as telecommuting/teleconferencing (people do not feel part of organization)

- Change in social behavior at basic level. Climate change affects relationships among people
- Change in distribution of precipitation throughout year will impact businesses.
- Lack of knowledge causing fear.(1)
- Unknown role in changing manufacturing industry (production and distribution of widgets)
- Future changes in regulatory climate (carbon cap, trade) are unknown
- Unknown cost of production/decommissioning
- Globalization has caused all consumers to be price sensitive (3)
- How can I get by with least cost? Individuals, companies, etc.
- Who pays where in the chain of production, distribution, consumption?

7.0 ADAPTATION

Following the discussion of potential risks, the Study Team presented stakeholders a number of adaptation measures identified in other jurisdictions (Chapter 5) and then solicited input on adaptation measures for Fredericton based on the Environment Canada scenarios (Chapter 4). Socio-economic, infrastructure and environment issues were all discussed. While stakeholder comments were wide ranging and covered all aspects of life in Fredericton, a number of the issues dominated .

Following is a summary of the adaptation measures identified by the stakeholders. The bracketed number at the end of selected comments is a record of the number of charette participants who considered the comment a priority.

7.1 Built Environment/Housing

The predominant adaptation issue was the built environment, specifically housing. Other predominant issues brought forward such as transportation and sustainable development are directly related to the built environment. Following is a summary of key points brought forward related to the built environment/housing;

- All new homes designed for grey water reuse (8)
- Design and build sustainable buildings (6)
- Tax break for green buildings (6)
- Incentives should be provided for sustainable buildings (5)
- Geothermal as an energy source both public and private (5)
- Multi- user buildings (4)
- Retrofit existing homes and buildings for energy conservation (3)
- Improved conservation measures (2)
- Building Codes have to be revised (roofs, slopes, density) (2)

- Encourage less energy use. Build zero energy ready homes (2)
- Use water from river as a geothermal source (2)
- Affordable housing should be built to be sustainable (1)
- There must be increased emphasis on the quality of the building
- Increased building inspections.
- Storm proof homes.
- Low impact development- green infrastructure, green parking lots.
- Conservation design- work with landscape, not against it.
- Green building-grey water, energy efficiency.
- LEED Certification -lead by example.

7.2 Transportation

The second most discussed issue after the built environment/housing was transportation**.** Following is a summary of key points brought forward related to transportation:

- Encourage active transportation (safety, exercise, green, non-automobile) (5).
- Increased need for facilities to support pedestrian/bicycle use (5)
- As a pilot project, close downtown streets to automobiles.(1)
- Regional daily bus system to outlying areas (1)
- More money in public transportation. New low emission busses.
- Trails bikeways, transit master plans
- Park and ride, carpooling
- Secure parking for bikes, free bikes
- Alternative sources of transportation.
- Access roads required for emergency vehicles

7.3 Planning and Sustainable Development

A number of adaptation measures identified by stakeholders under planning and sustainable development could also be considered as adaptation measures for both the built environment/housing and transportation. Following is a summary of key points brought forward related to planning and sustainable development:

- Develop sustainable neighbourhoods (10)
- As a first step, develop a demonstration model neighborhood- try it show it (5)
- Maintain existing wetlands (wetlands store water) (5)
- New policies required for lawn construction, site preparation, and landscaping (3)
- Limit the amount of garbage per household. User fees for garbage (3)
- Economic incentives required to encourage sustainable development (tax breaks) (2)
- Facilitate alternative energy choices (2)
- Municipalities must take a lead role (1)

- Encourage underground construction (1)
- Encourage alternative systems
- Greater agricultural diversity locally to mitigate impacts of supply issues nationally/internationally (3)
- Buy local
- Plan for climate change. Not many town planners know how to plan for adaptation/mitigation

7.4 Municipal Services

Following is a summary of key adaptation points brought forward by stakeholders related municipal services:

- Increased cooling demands-municipal cooling system of greater efficiency than individual residential units (4)
- Continue with good communication plan (4)
- Municipal grey water line (1)
- Buried power. Turbines in river to generate power
- On-site water retention-ponds
- Wide implementation of zero discharge
- Reduce water use. Limit non-essential water use (car washing/lawn care) (1)
- Increase fees for water/sewerage service

7.5 Parks and Recreation

Following is a summary of key adaptation points brought forward by stakeholders related to parks and recreation:

- More trees throughout City (6)
- City Forest Management -clean up the forests, parks, multiage stands, shade/ protection from winter wind (1)
- Clean up river so we can swim. Sand beach near green (1)
- Build more recreational facilities
- Plastic skating rink York Rink, etc (4)
- Build more all weather fields (1)
- Charge more (user fees) for recreational facilities
- Artificial lake for pools recreational fields, summer use-use the snow

7.6 Education

The stakeholders, in assessing the various sectors, also identified a need for education. Following

is a summary of key points brought forward by stakeholders related to education:

- Educate the public on climate change, provide clear definitions in understandable language for the terminology (carbon footprint, carbon credit, carbon tax) (7)
- Teach the kids to educate the adults (7)
- Research chair in Green Planning, Architecture and Design (6)
- Advertise innovative buildings- Convention Centre LEED building (2)
- Public education on climate change, water usage
- Lack of understandable language
- Green technology show –home, business
- Demonstration Neighbourhood –Neills' farm, woodlot
- Awareness equates to action.

8.0 SUMMARY and CONCLUSIONS

8.1 Stakeholder Input

There were a number of recurring messages delivered by the stakeholders to the Study Team. The following is a summary of the most repeated messages from the charette, townhall meetings, and web page.

There was a large stakeholder emphasis for more sustainable housing and neighbourhoods better able to handle the future climate and meet the needs of city residents. Adaptation ideas put forward for the built environment /housing include:

- Housing with grey water systems which would decrease wastewater and demand less of the City's infrastructure and water treatment, especially during summer months when shortages will become more common.
- Neighbourhoods and housing taking advantage of renewable energy sources, such a geothermal, which could be developed by the City for institutional buildings or neighbourhoods, or for individual housing.
- Incentives, such as tax breaks to encourage such sustainable new and retrofitted housing.
- Pilot projects of sustainable housing. These pilots might begin with affordable or social-housing projects, which would be key examples lowing the long-term cost for the user, improving the quality of the housing.

Stakeholders indicated a key risk factor in improving the building stock was that a disproportionate burden for housing improvements would be placed on those least able to bear cost.

Adaptation ideas put forward for transportation include:

- Encourage bicycle and pedestrian mobility (zero emissions, less noise, less traffic congestion, less costly infrastructure, and a healthier lifestyle).

- Improved trail and road system to encourage active transport, such as through more bike lanes.
- Provide other facilities to reduce barriers to bicycle use (bike racks around town).

Stakeholders recognized that the City has an excellent diversity of tree and forest cover, as well as an extensive urban wetland system that supplies much of the City's clean drinking water. These ecosystems were identified as being hugely valuable to the City and its residents for both the aesthetic value (i.e. quality of life, tourism, recreation) and also the natural services value (i.e. clean air, water, flood protection). Given the increased encroachment on these ecosystems, stakeholders indicated that it is very important to protect and restore the trees and wetland areas of the urban and surrounding area.

There was an overall consensus among stakeholders that education is an indispensible tool to address both climate change mitigation and climate change adaptation. Stakeholders identified a need to be provided the public with definitions and understandings of the language and terminology for climate change, so that everyone could have a clear conception of what the City is facing and how it can adapt. Public outreach and information could be complimented by an educated and engaged youth, which would learn and experience the issues and solutions at school, and then bring them home and into the community. Children are recognized as a main conduit for the climate change message, because it is their future that is at stake. Stakeholders also identified a UNB Research Chair in Green Planning, Architecture and Design to develop and support adaptation to climate change issues

8.2 Conclusions

Based on observations throughout the project plus input received, it is very evident to the Study Team that Fredericton stakeholders are very knowledgeable on climate change and its potential impacts. There is also evident a strong will to make both the social changes and the capital investments required to adapt to climate change.

The predominant issue of the stakeholders involved was our existing and future built environment, specifically housing. Stakeholders expressed a strong desire to increase the quality of the built environment, either by retrofitting existing stock, or designing and building new structures to a much higher quality than is accepted today. Stakeholders are looking to the City to lead the way, both through higher building standards and increased enforcement of these standards.

In addition to the increased quality of our built environment, stakeholders strongly supported the concept of "sustainable development". Sustainable development would include all aspects of development from initial sitting through to design, construction and maintenance.

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